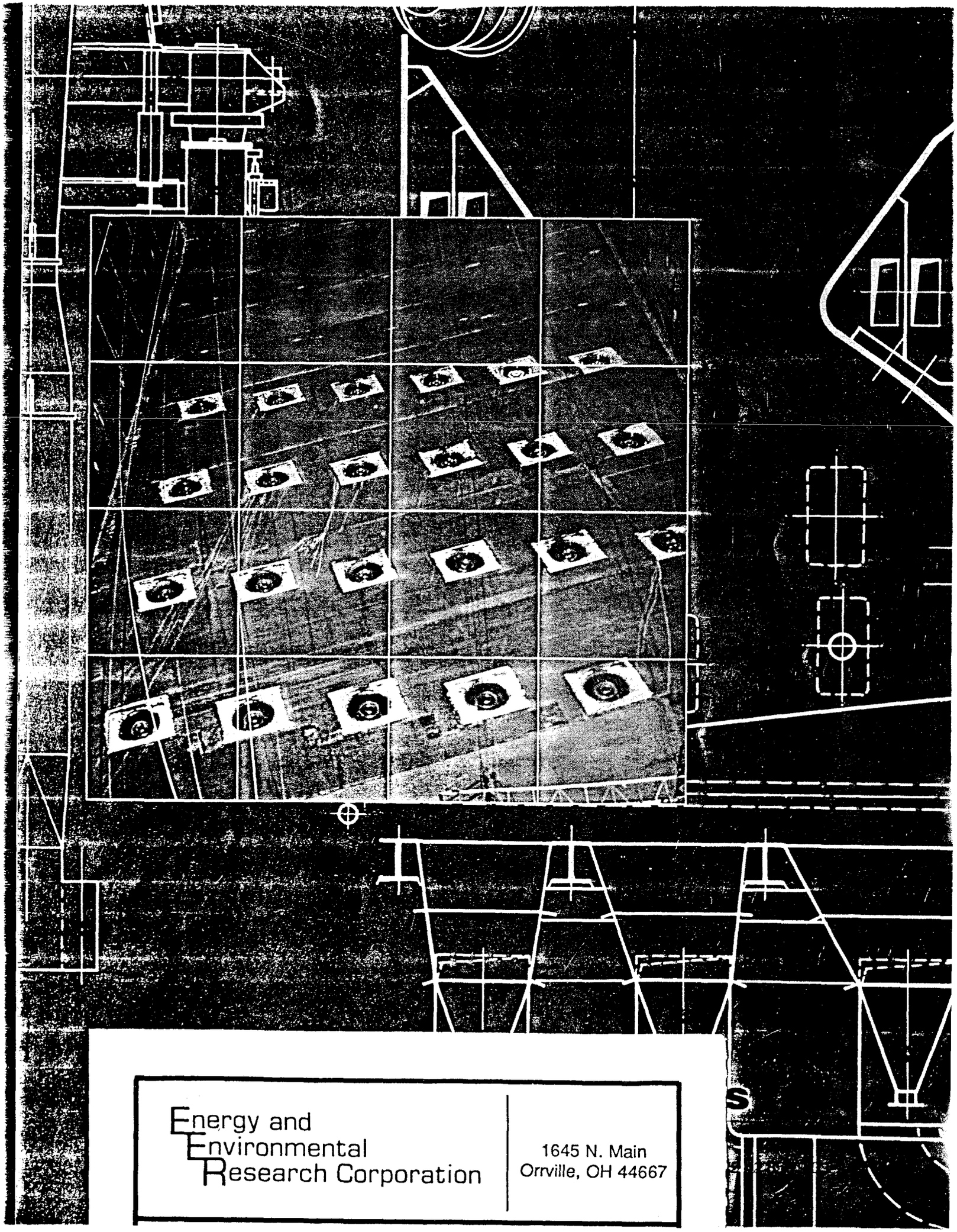


Energy and
Environmental
Research Corporation

1645 N. Main
Orrville, OH 44667

Results in Reliable Units

A boiler plant must be available all through the planned lifetime. That is why quality in every detail is a necessity. Even a minor problem can bring the entire plant to a stop resulting in very inconvenient loss of profits. Each detail in a BWE burner has been carefully designed and checked. Subcontractors are selected under the strict requirements from the BWE quality management system.

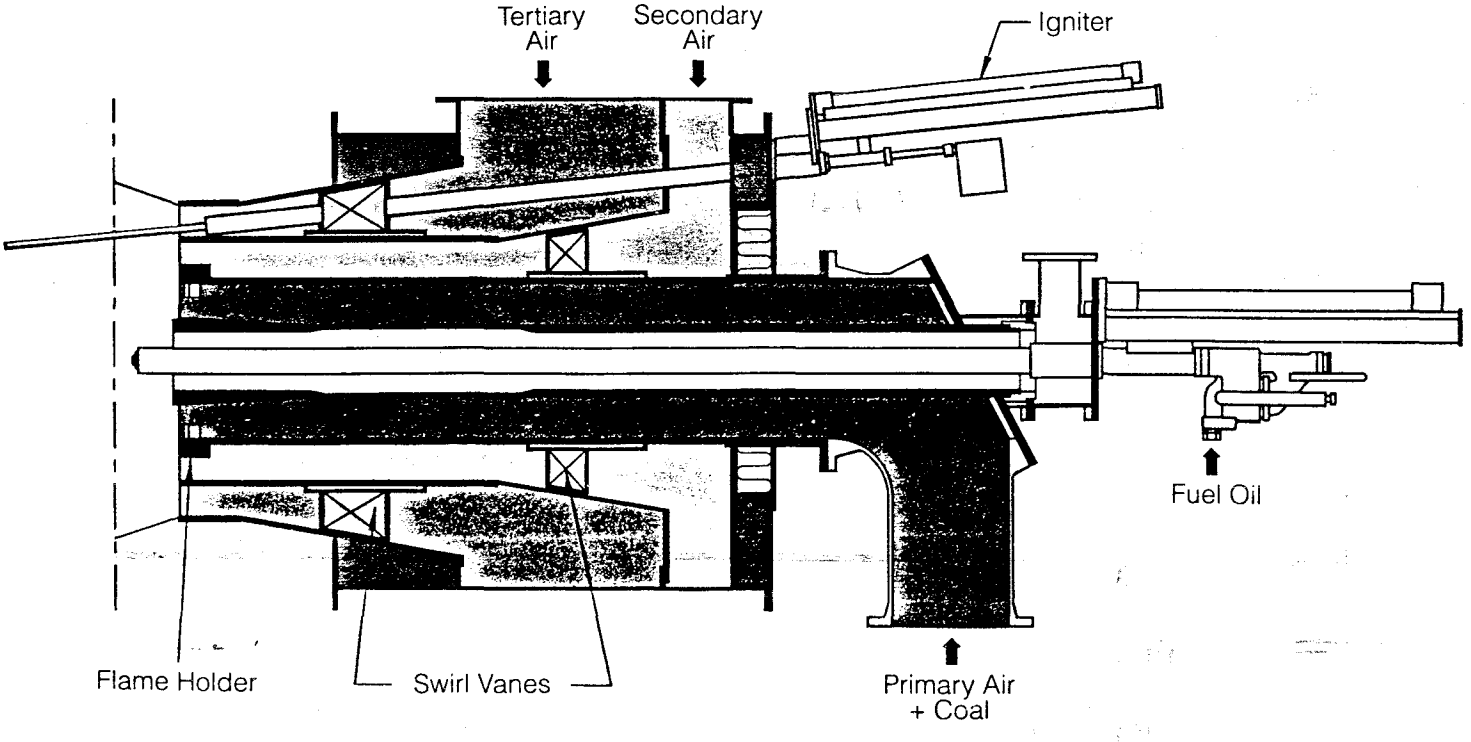
Inspection and Maintenance

The BWE Type 4AF burner is designed in modular units that permit access to all the vital parts of the burner without dismantling the register house with its insulation and suspensions. Further, the carefully prepared design means that the inspection of the burner can be performed using only very little time for dismantling and mounting.

The individual modular units and the order of dismantling are:

1. Core air tube and oil lance with retractable mechanism
2. Coal tube, flame holder and secondary air turbolator with drive
3. Outer front plate, igniter and flame scanner sight tube
4. Secondary air cone and throat with tertiary air turbolator
5. Tertiary air cone and throat

The coal pipe elbow wear parts comprise a wear plate behind the elbow, a wear lining in the elbow and a wear tube around the core air pipe.



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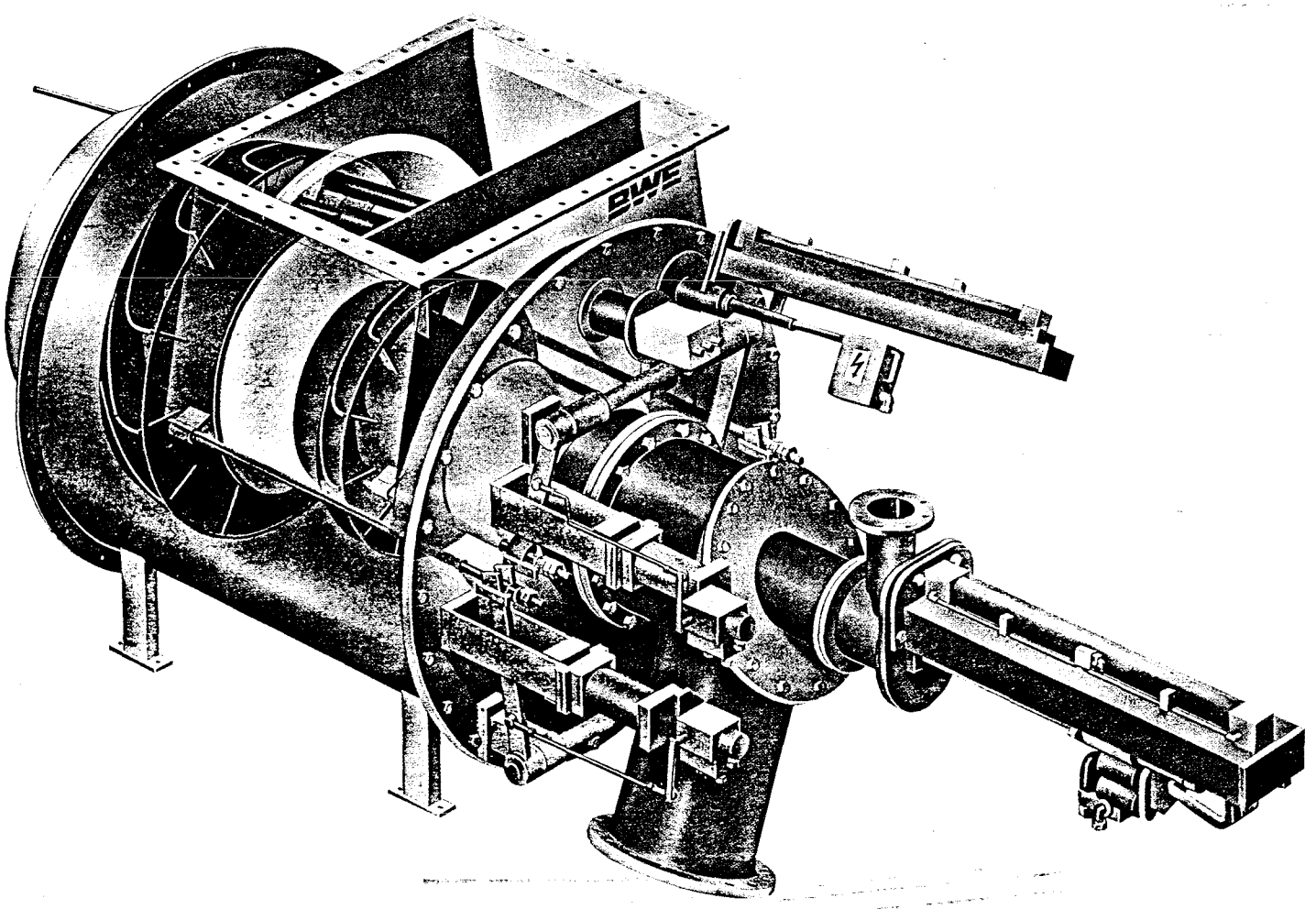
BWE Type 4AF Attached Flame Low-NOx Burner Includes Special Qualities



- Combustion air supply through separate secondary and tertiary air passages
- Variable secondary/tertiary air flow distribution
- Variable secondary air swirl and tertiary air swirl
- Low primary air and pulverized coal velocity
- Flame holder attached to coal pipe

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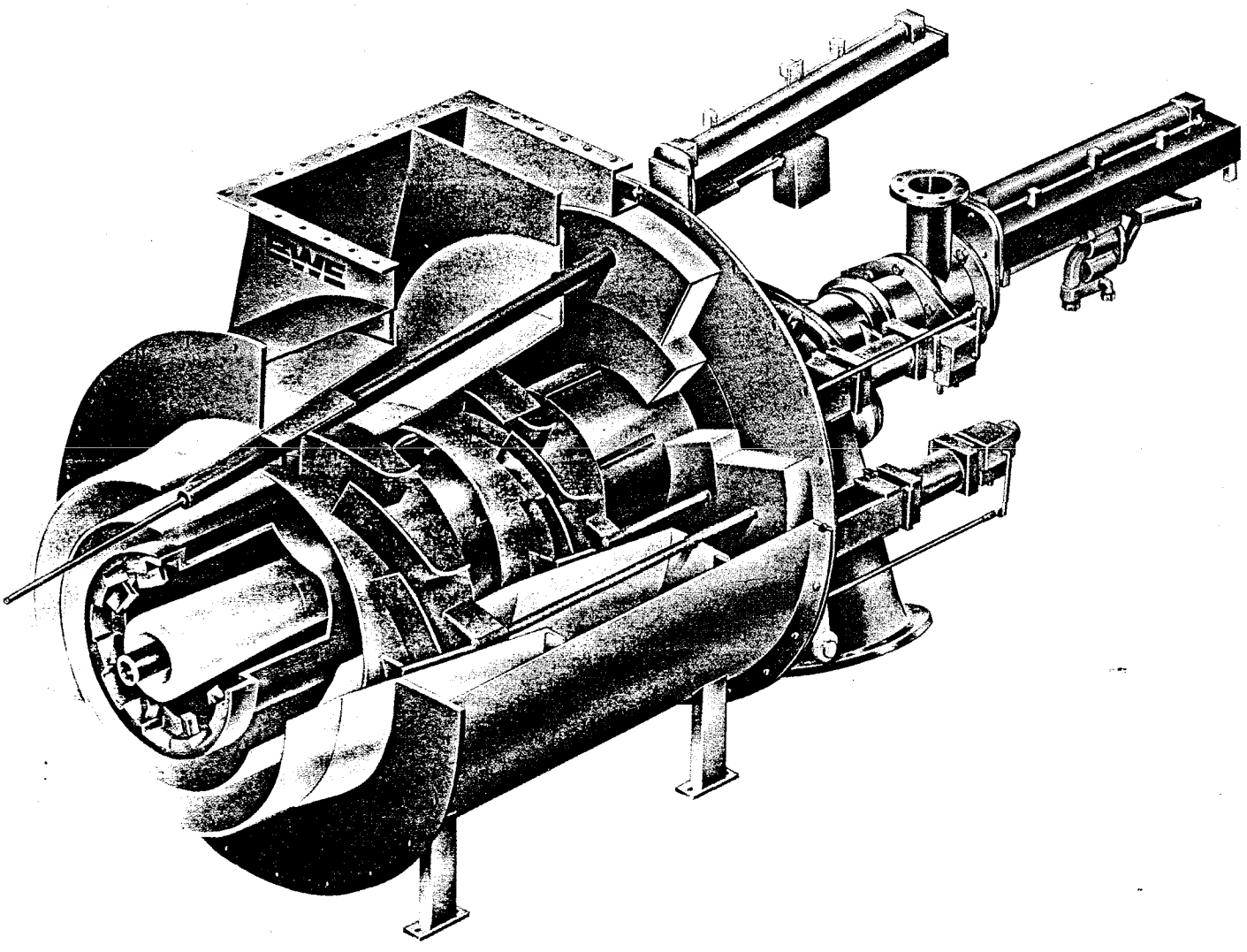
Low-NOx Burners



The BWE Type 4AF Attached Flame Low-NOx burner is a combined coal/oil burner with the same thermal capacity on each fuel. The burner features 4 independent air flows: the primary, the secondary, the tertiary and the core air flow.
When burning coal, the primary air flow conveys the pulverized coal to the burner throat. The attached Low-NOx coal flames are maintained by the flame holder, which is mounted at the end of the coal pipe. The flame holder establishes local recirculation zones and promotes local mixing between the coal and the secondary air.
The secondary air flow passes through the swirl vanes in a turbolator in order to establish the correct conditions for ignition of the coal. The tertiary air flow is the main part of the combustion air and ensures the completion of the combustion. Dependent upon the position of the turbolator in the conical part of the tertiary air register, a proportion of the tertiary air bypasses the swirl vanes in the turbolator.

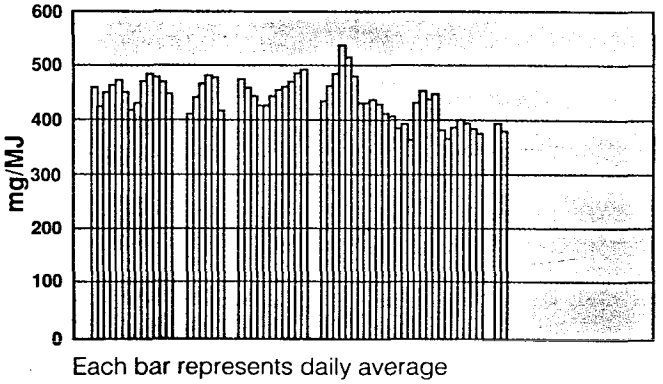
The automatic control drive for the tertiary air turbolator makes it possible always to establish the desired flame shape, thus accomodating the available space in the furnace. The excellent capability to control the flame shape is one of the main features to prevent flame impingement on the furnace walls.
The core air flow is cooling the fuel oil lance when the burner is out of operation.

BWE Reduces the Emission of NOx from Asnæs Unit 4 by 50 %

In 1987 it was decided to replace the conventional burners used till now at Asnæsværket Unit 4 (Kalundborg, Denmark) by Low-NOx burners. The installation of these burners should be co-ordinated with other conversions of the boiler and be terminated by the end of 1989.
BWE accelerated the development of a prototype Low-NOx burner, that was tested in the middle of 1988 and developed further in a pilot plant. This continued development and testing resulted in a quite new type of BWE Low-NOx burners with an emission of NOx of less than 50 % in comparison with conventional coal burners.

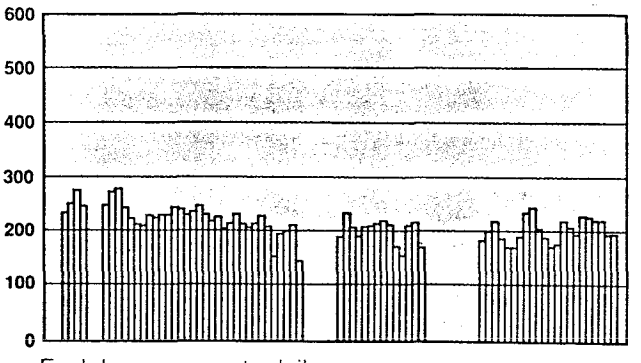
During the first three months of operation for the new Low-NOx burners at Asnæsværket, the average daily emission of NOx was measured to 220 mg/MJ (≈ 590 mg/Nm^3).
By way of comparison, the emission of NOx during the same period the previous year averaged to ca. 440 mg/MJ (≈ 1180 mg/Nm^3). Thus, the emission of NOx has been reduced by 50 %, while the unburned carbon in the fly ash remains unchanged at less than 5 %.
The fired types of coal have come from Poland, the United States, Colombia and Canada.

NOx emission, old burners
Asnæs Power Station, Unit 4 - January-March 1989

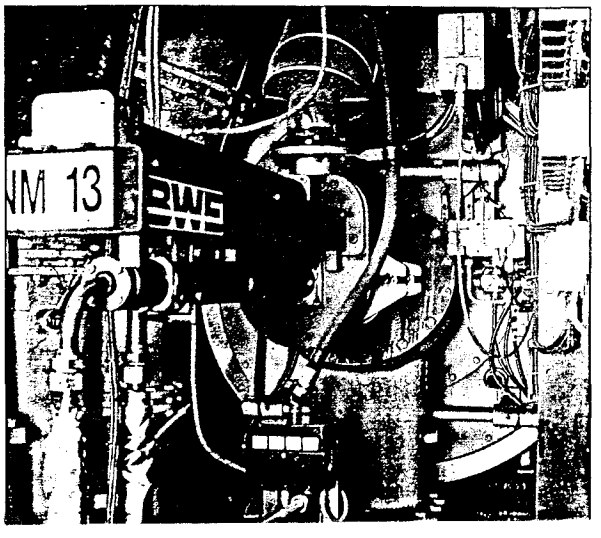


Each bar represents daily average

NOx emission, new burners
Asnæs Power Station, Unit 4 - January-March 1990



Each bar represents daily average



ASNÆS POWER STATION
Unit 4
Kalundborg, Denmark

Specifications:
Power capacity ..... 270 MWe
Steam capacity ..... 840 t/h
BWE Type 4AF Attached Flame

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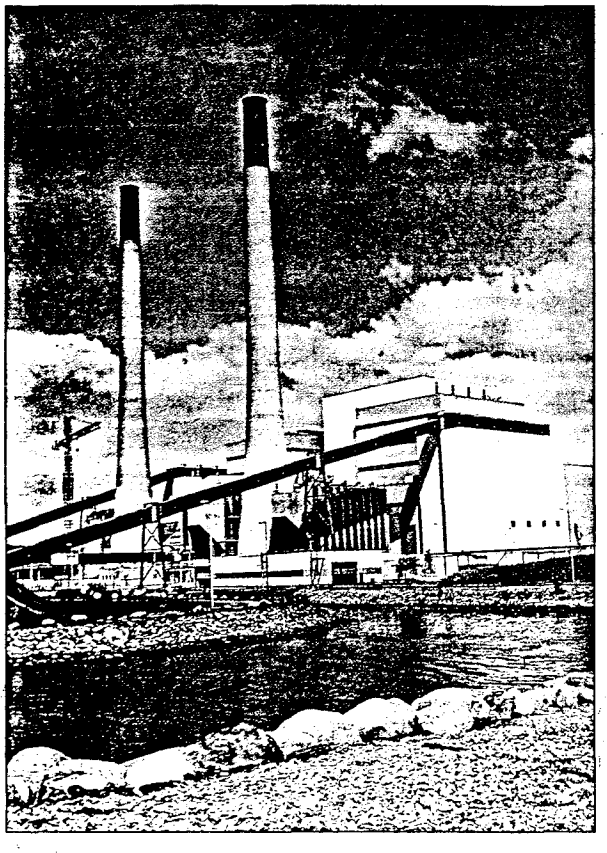
Is One of Our Specialties

Throughout the sixties and in the beginning of the seventies a large number of oil-fired boilers were built. The stable and extensive import of oil from the Arab States contributed heavily to this development.
In 1973, the price of raw oil was multiplied by four, and the prices rose gradually throughout the seventies until another price boom in 1979-80 doubled the prices. This dramatic development of the price of fuel oil for power production had serious consequences for the power generating industry. Coals for power production became competitive, even they had to be transported over great distances, for instance from Australia to Europe.
During the next decade, BWE converted quite a number of oil-fired boilers to coal firing, with a total power capacity of more than 3000 MWe. In order to minimize the customer's costs, the conversions were usually carried out in an extremely short time, a challenge that BWE had the intention and manpower to meet. The performances and the experience gained from the execution of these exceedingly complicated conversions as well as our general developing and engineering tasks make BWE one of the world's most experienced manufacturer of coal-fired boilers and combustion equipment.



Because of the public's increasing concern about the emission of NOx from the power stations and consequently about the environmental influence, BWE decided early in the eighties to initiate a development of a Low-NOx combustion technology. A small part of the Nitrogen-content in the atmosphere and up to 80 % of the Nitrogen bound in the fuel are oxidized during the combustion and form NO or NO_2 (NOx). Coals for power production contain bound Nitrogen, normally 1 to 2 %, a fact that causes the large emission of NOx from the conventional pulverized coal combustion.
Coal is the only energy resource in the world, also available in sufficient quantities in the centuries to come. That is part of the reason why it is a primary obligation for BWE to develop the LOW-NOx combustion of pulverized fuel. The fact that it is an economic advantage to prevent or minimize the formation of NOx in the very combustion process than building catalytic plants to reduce the emission of NOx in a subsequent cleaning of the flue gases has also contributed essentially to this development.
The first BWE Type 4A Low-NOx coal burners were installed in Unit 1 at Stignæsværket, Denmark in 1983 and have been running since then. These burners, still being in operation and expected to have a longer lifetime than conventional coal burners, have reduced the emission of NOx from Stigsnæsværket considerably. During the operation the BWE Low-NOx burners have been fired with coals from all over the world, for instance from Australia, Colombia, the United States and Poland.

BWE Low-NOx burners are capable of meeting all essential requirements and needs, for instance:

- Reliable ignition and stable flames
- Wide control range
- No slag formation or corrosion problems in furnace
- Less than 5 % unburned carbon in the ashes
- Low maintenance costs
- Low emission of NOx

STIGSNÆS POWER STATION
Unit 1
Skelskør, Denmark

Specifications:

Power capacity	150 MWe
Steam capacity	470 t/h
BWE Type 4A Low-NOx coal/oil burners	12 off
Retrofitted in	1983

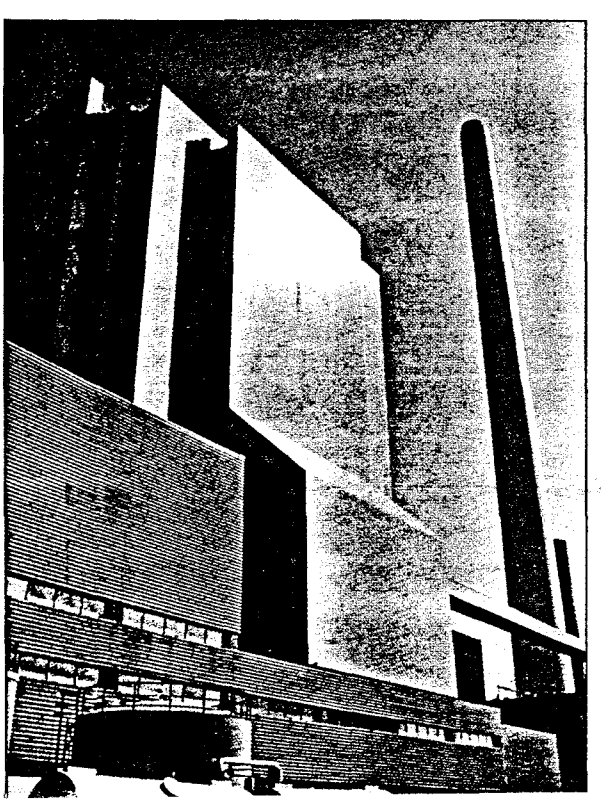
For More Than 140 Years We Have Designed and Manufactured Steam Boilers

In 1852, Burmeister & Wain manufactured its first stationary steam boiler, but already in 1843, the first marine boilers were produced. In the years to come, a large number of steam engines and steam boilers, central heating systems, and paper machines were designed, all of a quality that could be described as the high technology of that time. Burmeister & Wain boilers should be the boilers that stood for the supply of steam for the industrial revolution in Denmark - in the form of marine boilers, industrial boilers, and power station boilers. The extensive knowledge acquired since then has given a good foundation for the continuous development of the company's products - for the benefit of customers in Denmark as well as in many countries all over the world.

Early in 1980, Burmeister & Wain Energy A/S was founded as an independent company, and later in the year it was merged into the West German Lentjes Group. The following year BWE delivered the so far largest coal-fired power station boiler in Scandinavia - of a capacity up to 2000 tons of steam per hour (700 MW electricity) - and BWE is the only company in Scandinavia having its own design of power station boilers of this size.

Throughout the eighties, BWE has carried out a large number of different energy and pro-environmental projects and has presented significant solutions, based on own highly advanced engineering and know-how. Some examples are:

- Development of Low-NOx pulverized coal combustion technologies to NOx-values less than 180 mg/MJ (≈ 500 mg/Nm^3).
- Development of Low-NOx pulverized coal burners capable of reducing the emission of NOx by 50%. Ideal for retrofitting conventionally fired boilers.
- Boiler plants installed in the various continents - from Svalbard in the Arctic Ocean to Botswana in the Southern Africa. BWE has also supplied the boiler plant to the most pro-environmental coal-fired power station unit in Europe: Unit 9 of Walsum Power Station, West Germany.
- BWE has supplied the world's largest peat-fired power station boiler to Uppsala Kraftvärmeverk, Sweden.
- Bark-fired boiler plants installed in Europe, from Sweden in Scandinavia to Czechoslovakia in Eastern Europe.
- Design and erection of a DARS-system (Direct Alkali Recovery System) at Fredericia Cellulose A/S, Denmark. This system removes damaging waste products from the production process of straw-based pulp, simultaneously recovering chemicals and producing steam for the process.



ASNÆS POWER STATION
Unit 5
Kalundborg, Denmark

Specifications:
Power capacity ..... 695 MWe
Steam capacity ..... 2000 t/h

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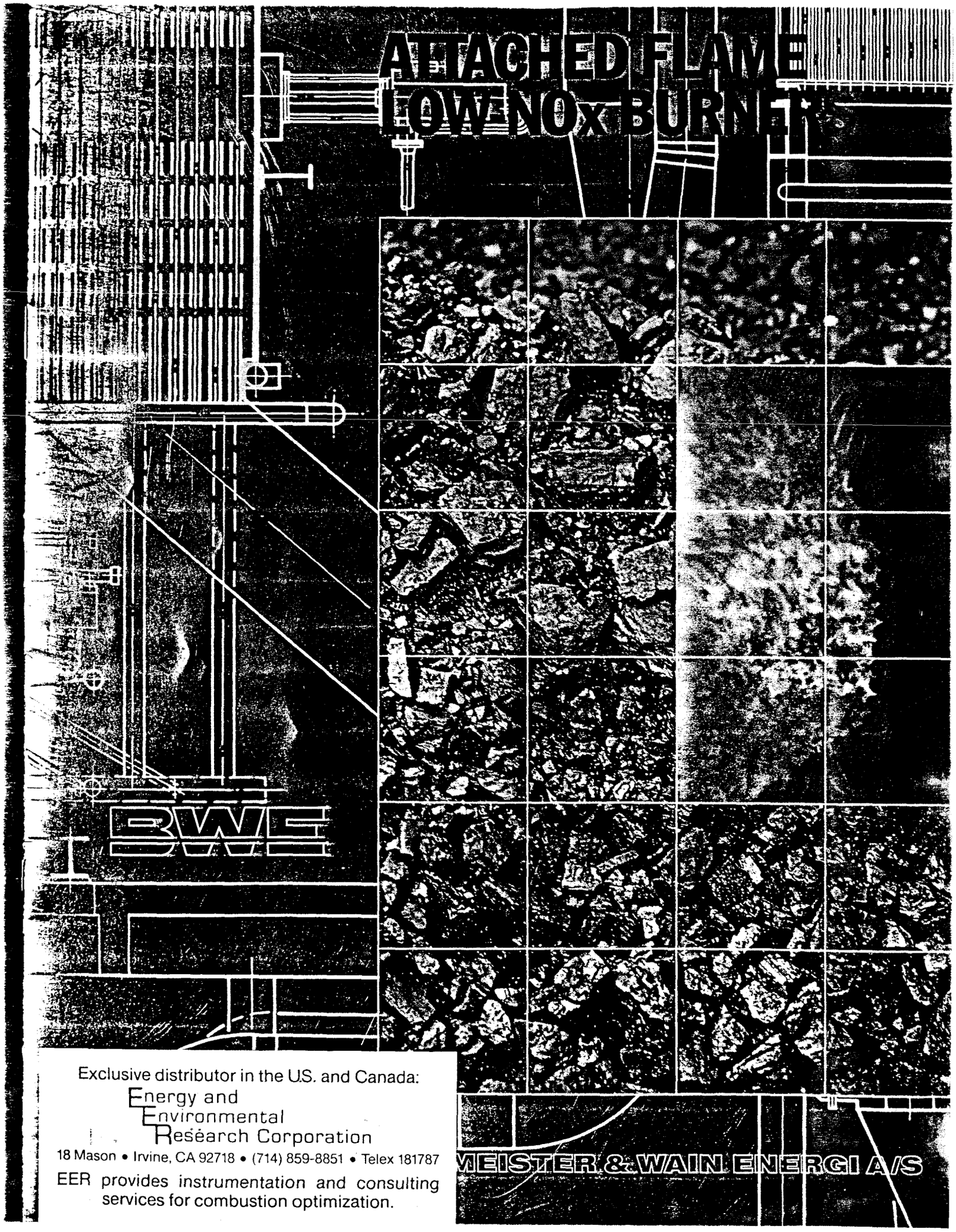

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